United States Department of Agriculture
Agricultural Adjustment Administration
North Central Region
Cooperating with
U. S. Bureau of Agricultural Chemistry Engineering
Corn ~~Sotrage~~ Storage Investigations

A PRELIMINARY PROGRESS REPORT OF OBSERVATIONS OF THE STORAGE OF DRY SHELLED CORN FROM NOVEMBER 1939, TO MAY, 1940[1]

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The purpose of this report is to present a brief summary of the observations of the condition of dry shelled corn placed in storage in the fall of 1939. A number of selected bins have been inspected at intervals of several weeks shortly after they were filledlast fall. The counties in which regular inspections have been made together with the number of bins inspected in each county are as follows:

Minnesota:	Freeborn	2
Iowa:	Boone	3
	Cherokee	2
	Franklin	2
	Calhoun	6
Illinois:	DeKalb	6
	Shelby	4
Indiana:	La Porte	7

Except for reference to a few specific cases of storage in Illinois and Indiana, this report covers primarily observations in Minnesota and Iowa, since the data from the former states have not as yet been fully reviewed.

[1]Part of Bankhead-Jones Research Project SRF-2-70, "Investigations of Farm Storage of Corn."

At each inspection temperature readings and samples for grade determination were obtained from the center and next to the walls in each bin at several different depths, namely, (1) next to the floor, (2) at mid-height, (3) in the upper six to eight inch layer, and (4) at the top surface. Duplicate samples from a number of selected bins representing different conditions have been taken for fat acidity tests. A portion of each of the samples taken has been placed in the constant temperature room maintained at 77° F. to incubate any live insect eggs or larvae which might be present.

Accompanying this report is a copy of the form used for recording information of the samples obtained from a bin in Boone County, Iowa, at one of the inspections.

Temperature Observations

The temperatures observed to date give some indication of the relative influence of a number of factors. There is considerable lag in temperature of the corn in the center of the bins behind that of the mean air temperature as indicated by fig. 1. It may be noted that the temperatures in the center of Bin 23 were from 5 to more than 15 degrees higher than that of the air during the period from the first part of November to the end of February.

As would be expected the lag in temperature of the corn next to the walls is much less, being only a few degrees different from the mean air temperature. Whether or not the corn in the center of the bins will be as much cooler during the spring and summer as it was warmer during the fall and winter remains to be observed. Judging from the observed temperatures in the center at mid-height and next to the floor during April, it appears that

the temperature of the corn in this part of the bin will be 10 to 15 degrees below the mean air temperature during the remainder of the spring and early summer. The mean monthly air temperatures to be expected at the place where the bins for which the data in fig. 1 are shown, is indicated by the normal mean monthly temperatures.

The temperature lag in the smaller bins is appreciably less than that in the larger bins. For example, the difference in temperature at the centers at mid-height of two 1250 bushel steel bins 14 feet in diameter, which are located in Freeborn County, Minnesota, and that of the outside air was only about one-third to one-half that of Bin 23 which is 18 feet in diameter and of 2000 bushel capacity. However, due to the lower temperatures to which the center portions at mid-height of the smaller bins had dropped during the winter, their temperatures during the latter part of April were still about 9 degrees lower than the larger bins. The average center temperature of the larger bins was 35° F. and that of the smaller bins was 26° F. during the latter part of April.

Where live insects were known to exist in bins, especially in the parts of the bins where the insects were concentrated, the temperatures were noticeably higher than in the other parts of the bins or than in bins with corn not infested with live insects. In a few cases where the insects remained alive throughout the winter, temperature of 75 to 90° F. were being maintained even during the latter part of March. The noticeably higher temperatures in the center at mid-height in Bin 6 (fig.1.) during November and the first part of December was at least partially due to the insect infestation observed early in the storage period during the latter part of October, at which time the bin was fumigated with carbon disulphide. As

live insects were not observed in this bin at any of the subsequent inspections, the fumigation was effective in killing all the adult insect population, and consequently the bin cooled rapidly during the latter part of December, so that its temperature at the center at mid-height was the same as that of Bin 23 during the latter part of April.

In one of the CCC bins in southern Illinois, badly infested with grain moth, the temperatures in December were 53 degrees at the surface and 78 degrees 15 inches below the surface.

Moisture Content

With the exception of the surface and upper layers, very little change in the moisture content of the corn was observed as may be noted in fig. 2. The surface layer in the center of the bins in particular increased in moisture content due to the entrance of snow through the roof ventilators. The surface layer in parts other than the center increased from one to two percent, due, in all probability to the absorption of moisture from the air. As evidence of this fact, in a similar bin in which the corn was covered with a layer of moisture proof paper, the increase in moisture content of the surface layer of conr was only very slight, namely from 10.6 to 11.1 percent since last November.

No increase in moisture content has been observed in the corn next to the floor up until the present time. The corn next to the floor and in the center of the bin at mid-height has been drier than in the other parts of the bin. The corn next to the bin boards in the side door has been observed to be about 1% higher in moisture content than the corn next to other

portions of the wall. However, this has been observed only in one bin where the door faced north.

The only serious increase in the moisture content of shelled corn has taken place in the top surface and upper 8 inch layers, and this condition has been observed in only a very few bins, and may be attributed to the following causes.

1. Entrance of snow through center ventilator.

Almost all the CCC steel bins inspected had their ventilators sealed with burlap. But in spite of this precaution, snow entered some ventilators, either because the burlap was blown out of place, or because it had been poorly installed. In some instances, piles of snow from 12 to 18 inches in diameter and from 4 to 8 inches high were found on the corn under the ventilators. With the subsequent thawing of this snow the moisture content of the top layers of corn increased, but in most cases, only to about 17 or 18% on the top surface and to 13 or 15% in the upper 8 inch layer. In these instances, the top surface corn dried down to about 11% and the upper 8 inch layer to about 12.5% by April 30th. However there was one case observed where the ventilator was not sealed with burlap, and where so much snow had blown in that it had caused the moisture content of the corn in the area under the ventilator to become so high that it had dried down to only 17.7% by April 18th. On that date, there was a mass of spoiled musty corn about 12 inches in diameter and about 6 inches in depth under the ventilator.

2. Presence of live adult insects.

The moisture content of the top layer of corn in a few farm bins was observed to be excessively high, and in one case 30 bushels of spoiled

corn had been removed from the surface of a 2400 bu. granary. There were no openings in the roofs to allow the entrance of moisture, but upon examination of samples taken from the lower layers of corn, they were found to be heavily infested with insects and had temperatures of from 75 to 90° F., although their moisture content was only about 10 percent. The cause of the excessive moisture content of the corn in the cooler top layer of these infested bins is undoubtedly due to the condensation of moisture produced by the insects as a result of their respiration. After the insects were killed by fumigation, the lower layers cooled down from 20 to 30 degrees in a few days' time.

Insect Infestation.

Two of the selected CCC steel bins were known to contain live adult sawtoothed grain beetles at the time they were filled last fall. One of these bins was fumigated with carbon disulphide last October, and the other was not. Samples taken monthly from the fumigated bin have not shown any live adult insects up to April 23rd. Samples from the nonfumigated bin showed insects to be present in the middle and floor layers as late as December, but there have been no live adult insects observed since that time up until April 18th. However, samples from both the bins have been shown to contain live insect eggs or larvae, because live adults have been observed in them after they were given favorable incubation conditions.

Three farm bins in Iowa, and a few CCC steel bins in southern Illinois were the only bins observed where the insect infestation was concentrated enough to permit adult insects to maintain sufficiently high temperatures in the central portions of the bin to survive.

However, incubation of samples from all the bins inspected, shows that some of the fumigations with carbon disulphide and the low winter temperatures were not entirely effective in killing the insect eggs or larvae, and that few of the bins examined are entirely free from such infestation, although it is very light in a majority of the cases.

The higher moisture content of the corn in surface layer under the ventilator together with the higher temperatures under the roof, apparently was more favorable to subsequent incubation of insects at room temperatures. The center surface sample taken from Bin 6 on March 16th contained no visible insects, but after only 23 days in the incubation room it contained 50 live larvae, whereas a sample taken from the same location in the same bin on November 8th showed only 8 visible live insects after 55 days incubation. Samples taken from the drier lower layers of the same bin on March 16th showed no live insects after 37 days incubation.

Control of Insects in Stored Grain

Several significant statements relative to insects in stored grains were made by Dr. Cotton of the Bureau of Entomology and Plant Quarantine in a recent conference with him. In view of their important bearing on the insect problem some of them are given below:

1. Insects are more active in grains of higher moisture contents. In fact, insects are not able to survive in grains of low moisture content. In wheat, for example the critical moisture content is 9 percent.

2. The ethylene-dichloride-carbon-tetrachloride mixture is considered to be a good fumigant, although more expensive than carbon disulphide. It is as effective as carbon-disulphide when used at the proper dosage and because of its non-inflammability is recommended for use where there is any danger of fire.

3. One fumigation if properly applied and of the recommended dosage should kill all insects including the egg and larva stages.

4. Since insects are not active at lower temperatures, much insect activity may not be observed in 2000 bushel steel bins until the first part of July, providing they do not contain live insects in the spring, as there is about as much lag in temperature of the corn in the warming period in the spring as in the cooling period in the fall. This applies to bins located in Central Iowa and other areas where the mean air temperature is similar. The outer layers of corn which warm up quickest should be especially watched, however, for early summer development of infestation.

Damage:

From the data obtained to date there has been no increase in damage, although a few bins contained from ten to 18 percent damage in certain parts of the bin. Most of this was in the form of blueheart.

A few samples taken from the surface layer which contained considerable damage and which increased in moisture due to absorption and snow blown in through the ventilator, acquired a musty odor in a few days when left in the laboratory in cellophane bags.

It is perhaps needless to mention the damage which occurs in the top five or six inch layer of corn in a bin when it is badly infested with live insects. In a number of steel bins in southern Illinois and in three farm bins in Iowa the observed effect was the same. As has been indicated above moisture accumulates in the top five or six inch layer to the extent that it begins to form a rather hard crust and soon becomes molded. In the advance stages all of the layer becomes black with mold and some sprouting of the top layer of kernels was noted.

Fat Acidity

Fat acidity tests, which have been demonstrated to be a more reliable index of the soundness of corn than other current tests, are being made on several hundred selected samples from various bins. The results of these are not as yet available, but will be incorporated in a subsequent report. It is hoped that as observations from time to time are being made, the change in fat acidity might be observed.

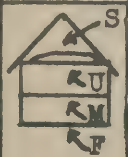
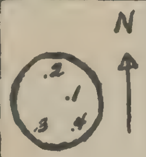
Adknowledgment

Acknowledgment is made for the interest and splendid cooperation of the members of the State and County Agricultural Committees in the States and the counties in which bins were inspected.

Sampling Date 3-16-40
Hour 11:10
Air Temperature 42 F
Grade Det. Date 3-18-40
Insect Reinspection Date

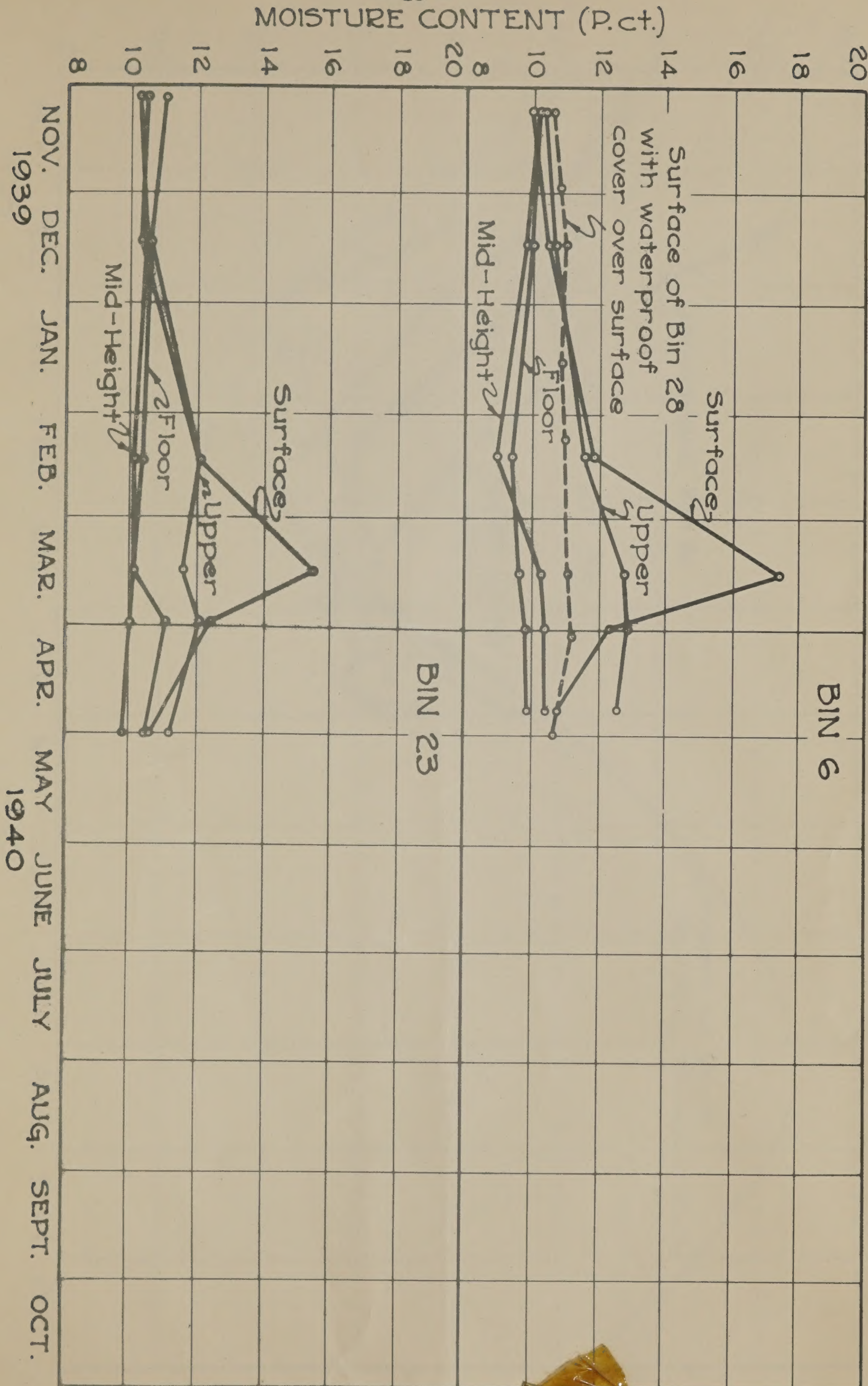
SURVEY OF SHELLED CORN STORAGE 1939-1940

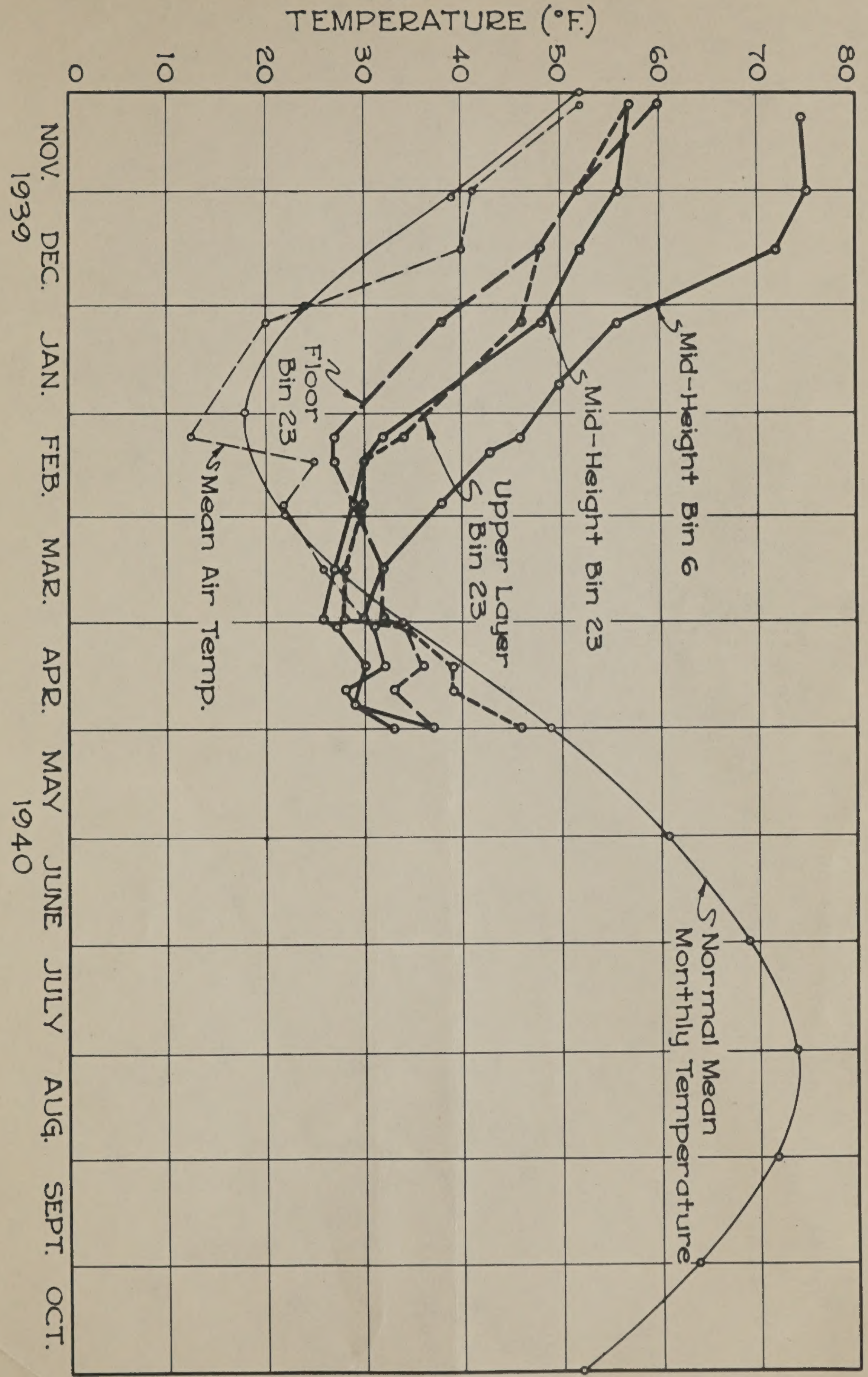
State Iowa
County Boone
Location Boone
Bin No. 6
Bin Capacity 2000 bu.
Bin Mfg. Butler

Location of Samples		°F Temperature	Grade Factors														Grade No.
 Section	 PLAN		Odor	Test Wt. lbs. per bu.	Moist %	Damage (P.ct.) Mold	Cob-Rot	Silk-Cut	Weevil	Rodent	Total	Foreign Material Rat Stools	Cracked Corn %	Coarse F. M. %	Total %	
Top Surface Layer Samples (S)	1		N	53.0	17.5	0.5	1.6	0.2	-	0.5	2.8	-	0.2	0.2	0.4	3Y
	2		N	55.5	13.7	0.1	0.7	-	-	0.3	1.1	-	0.3	0.2	0.5	1Y
	3		N	56.5	12.5	-	1.0	0.5	-	0.3	1.8	4	0.3	0.2	0.5	1Y
	4		N	56.0	13.2	-	1.3	0.2	-	0.5	2.0	6	0.4	0.2	0.6	1Y
	Av.		N	55.3	14.2	0.2	1.2	0.2	-	0.4	1.9	2.5	0.3	0.2	0.5	2Y
Upper Layer Samples (U)	1	31	N	57.0	12.8	-	1.4	0.4	-	0.4	2.2	-	0.7	0.5	1.2	1Y
	2	28	N	56.5	10.3	0.2	1.0	0.3	-	0.5	2.0	3	0.7	0.3	1.0	1Y
	3	28	N	56.5	12.5	0.1	0.9	0.6	-	0.3	1.9	-	0.4	0.2	0.6	1Y
	4	28	N	57.0	12.8	0.1	1.4	0.4	-	0.2	2.1	-	0.8	0.2	1.0	1Y
	Av.	28.8	N	56.8	12.1	0.1	1.2	1.4	-	0.4	2.1	0.8	0.7	0.3	1.0	1Y
Middle Layer Samples (M)	1	32	N	56.0	10.3	0.3	2.2	0.5	-	0.4	3.4	11	3.4	0.5	3.9	3Y
	2	29	N	56.5	11.9	0.2	3.0	0.6	-	0.4	3.2	-	1.1	0.4	1.5	2Y
	3	29	N	56.0	11.6	0.2	2.8	0.3	0.3	0.6	4.2	18	1.2	0.5	1.7	2Y
	4	29	N	56.5	11.6	0.4	1.6	0.5	-	0.4	2.9	13	1.0	0.5	1.5	1Y
	Av.	29.8	N	56.3	11.4	0.3	2.1	0.5	-	0.5	3.4	10.5	1.7	0.5	2.2	2Y
Floor Layer Samples (F)	1	29	N	57.0	9.7	-	1.7	0.2	-	0.5	2.4	3	2.2	0.6	2.8	2Y
	2	31	N	56.0	11.9	-	1.0	0.2	-	0.8	2.0	5	2.3	0.7	3.0	2Y
	3	37	N	56.0	9.7	0.2	1.8	0.3	-	0.9	3.2	4	2.1	0.6	2.7	2Y
	4	36	N	57.0	9.5	0.4	1.4	0.4	-	0.6	2.8	1	0.6	0.3	0.9	1Y
	Av.	33.3	N	56.5	10.2	0.2	1.5	0.3		0.7	2.6	2	1.8	0.6	2.4	2Y
Total Av.		29.8	N	56.2	12.0	0.3	1.5	0.4	-	0.5	2.4	4	1.1	0.4	1.5	1Y

Broken Seal Nos. 1634, 1835, 1836 Replaced Seal Nos. 1640, 1641, 1642

Field Inspection by T. R. Connor


MOISTURE CONTENT (P.ct.)
BIN 6
Surface
Upper
Surface of Bin 28 with waterproof cover over surface
Floor
Mid-Height
BIN 23
Surface
Upper
Floor
Mid-Height
20
18
16
14
12
10
8
NOV. 1939
DEC.
JAN.
FEB.
MAR.
APR.
MAY 1940
JUNE
JULY
AUG.
SEPT.
OCT.


TEMPERATURE (°F.)
0
10
20
30
40
50
60
70
80
NOV.
1939
DEC.
JAN.
FEB.
MAR.
APR.
MAY
1940
JUNE
JULY
AUG.
SEPT.
OCT.
Mid-Height Bin 6
Mid-Height Bin 23
Upper Layer Bin 23
Floor Bin 23
Mean Air Temp.
Normal Mean Monthly Temperature